

Annual Report

Wenatchee Basin Spring 2004 Steelhead Rotating Panel Survey

Abstract

In its first year, a random-design steelhead survey provided new information about steelhead spawning locations and abundance in Wenatchee basin. Redd detection probability appeared to vary with stream attributes and survey method (wading, boat, etc.) and should be explicitly considered in analysis. Year-one data reported here will allow refinement of the sample selection protocol to better target the desired population. These refinements to the protocol may enhance its application in other stream systems.

Introduction

The Wenatchee basin random-site steelhead redd survey is one component of a larger research program which applies a rotating panel design to collection of many aquatic physical and biological parameters throughout Wenatchee basin (see Hillman 2004). We conducted steelhead redd surveys on twenty-five stratified-randomly selected one-mile reaches in anadromous-accessible waters throughout the Wenatchee basin.

Stratification was based on gradient and channel order. To enhance consistency between steelhead, habitat, and snorkel sampling within the larger project, the same random stratification and sites were used for steelhead as for these other components. The stratification excluded streams with gradients over 12%, excluded streams not found on a 1:100,000 scale hydrography layer, and emphasized lower gradient and wadable (4th order and smaller) streams. Steelhead surveys were done on a sub-sample that was not above known anadromy barriers.

The protocol and survey timing was adopted from another project component: existing WDFW steelhead surveys of non-random (trend) reaches in Wenatchee basin, ongoing since 2001. However survey frequency was lower on our random sites (bi-monthly) than on WDFW non-random reaches (weekly).

Methods

Reach Selection

Our scope of work called for steelhead surveys in 25 one-mile reaches. Because survey feasibility was uncertain for some very remote sites, we began surveys on 26 reaches to ensure completion of at least 25 (figure one).

To find 26 suitable sites, it was necessary to consider 72 sites from the ordered list of stratified-random sites provided (i.e. 36% of the stratified-random sites were suitable). The principal reason for dropping a site was presence of an anadromous barrier downstream (table A1). Other reasons for dropping sites included: 1) the site did not contribute to fish or aquatic invertebrate production in any season (a criteria for exclusion from the larger study); 2) safety; 3) inaccessibility; 4) already surveyed weekly by WDFW; or 5) other reasons. A full list of sites kept and dropped, and reason for dropping each site, is provided in Appendix A.

Our scope of work called for each reach to receive at least 3, and ideally 4, field visits. In 2004, 26 reaches received at least 3 visits, and 22 received at least four visits¹ (table one). In two reaches, where new redds were seen on the 4th visit, we made additional visits to be certain we did not miss late spawning. In fact we did not find additional redds on the extra visits. Five visits were made to Beaver Creek and six to Chumstick Creek.

Data Collected.

On each visit, redds were counted, flagged, and categorized, adult steelhead were noted, and water temperature was recorded. Redds were categorized as incomplete, complete, faded, or erased (see definitions in Appendix B).

Training, Quality Control, and Calibration.

All our crew members had prior experience with redd surveys; however not all had prior experience with redd surveys for steelhead. Those without prior steelhead experience accompanied an experienced WDFW crew on an early season survey on the Wenatchee River. An additional training for crew hired later in the year was conducted on Mission Creek. Our crews were also trained and certified in first aid, CPR, avalanche beacon use, and ATV and snowmobile operation.

¹ Reaches receiving only three visits: Three reaches were remote and required several miles of travel over snow (Ingalls near the bull trout barrier, Rock Creek, and Chiwawa near Phelps). We attempted to access these reaches on four days (5 days in the case of Chiwawa near Phelps) but were only able to reach the site and conduct the survey on the final three visits due to access/snow conditions. The other reach receiving only 3 visits was Chiwawa at Big Meadow, where high flows precluded a 4th visit due to safety concerns.

Each crew received a Quality Control (QC) visit from one of two project leaders. All crews were identifying redds accurately and consistently.

Handheld thermometers used to measure water temperature were calibrated prior to the season (see Appendix C).

GPS purchased for the project were calibrated before the field season (see Appendix D). We developed an explicit protocol for GPS use specifying pre-planning, warm-up, projection, position-averaging, and information recorded (see Appendix D). Due to timing of funding availability, the project GPS's arrived mid-study, so some GPS coordinates were collected on borrowed, uncalibrated GPS. The borrowed GPS had no known problems, and coordinates collected appear correct.

Reach Access.

The protocol we used was developed for non-random survey locations by Washington Department of Fish and Wildlife (WDFW). In Wenatchee basin, most non-random (WDFW) steelhead surveys are conducted from pontoon raft, and a few are conducted by wading. All WDFW sites have driving access.

In contrast a random site may require many miles of non-driving access over trails or closed (snow-filled) roads. Snowshoes, skis, snowmobiles, and/or ATVs were variously used to access sites. A site that was accessible with snow cover could become inaccessible later, with spotty melt-out creating insufficient snow for snow access, but too much snow in spots for vehicle/ATV access, and distance precluding walking.

The best method for conducting the survey depended on stream width, gradient, instream obstructions, bank conditions, and flow. We used 4 methods: wading, pontoon raft, kayak, and bank-walking.

Wading, the most accurate method in smaller streams, was possible only when streamflow allowed surveyors to move freely across and through the stream. Many streams which are wadable at low flow are not wadable during steelhead spawning season. Nine of our random sites (35%) were wadable (table one).

Raft surveys are the preferred method in large systems, because while one surveyor guides the raft, the observer stands on a platform; the observer's eye level is several feet above the water surface, providing excellent visibility. Key concerns for raft surveys are vehicle access at put-in and take-out, and safety (which can vary with flow).

Kayaks, like rafts, have the advantage of being able to move across the entire stream surface according to the observer's desires. Because kayaks can be carried about ¼ mile on a trail, and are more easily maneuvered than rafts over or around instream obstructions, a double inflatable kayak was used when number of log jams, narrow stream width, or lack

of driving access precluded raft use. However from a kayak, redds are less visible to the observer, because the observer's eye level is typically only a few feet above water surface.

A fourth group of streams remains cannot be safely waded nor feasibly kayaked/rafted. Bank-walking is a good method for some of these streams, for example Negro and Marble Creeks, where the entire stream bed can be clearly viewed from a single bank, and banks do not have dense streamside brush.

In contrast, bank-walking seemed a much less effective redd survey method in wider streams such as Nason and Chiwawa. At most of our 4th order bank-walk sites, our access was limited to a single bank on all visits. In these streams our view of substrate was limited along the far bank, or behind obstructions such as boulders, even using binoculars. Survey efficiency was further reduced when banks were extremely brushy.

Based on the above, redd detection probability is likely affected by survey type and stream attributes and should be explicitly considered in analysis. Detection probability may be lowest in wide, brushy systems not surveyable from watercraft. Survey method used in each survey is listed in table one.

Results

Steelhead activity was observed in 7 reaches in 5 streams (Nason Creek, Peshastin Creek, mainstem Wenatchee, Beaver Creek and Chumstick Creek; see table one). In addition 8 steelhead redds were seen in Mission Creek between Sand Creek and East Fork Mission during a staff training (one visit).

Table One: Surveyed reaches

Reach num	Site num	Watershed	Stream	Survey Method	Date first surveyed	Date last surveyed	Num of surveys	First survey date with water temp >= 38.5 F	Surveys with water temp >= 38.5	Date first obsvd ST activity	Date last obsvd ST activity	Total Num Redds	Total Num ST
1	WC503432-001	Nason	Nason Creek below Coles C	B/K	4/1/2004	5/3/2004	4	4/1/2004	all	4/14/2004	5/3/2004	4	2
2	WC503432-003	Wenatchee	Wenatchee at Monitor	C	3/15/2004	5/24/2004	9	WDFW		N/A	N/A	0	0
3	WC503432-038	Chiwawa	Chiwawa at Big Meadow	B/K	4/21/2004	5/26/2004	2	4/21/2004	all	N/A	N/A	0	0
4	WC503432-063	Chiwawa	Rock Creek mouth	B	4/21/2004	5/3/2004	2	4/21/2004	all	N/A	N/A	0	0
5	WC503432-009	Chumstick	Spromberg Cyn	W	4/1/2004	5/4/2004	4	4/1/2004	all	N/A	N/A	0	0
6	WC503432-011	Peshastin	Peshastin at mouth	B	4/1/2004	5/4/2004	3	4/1/2004	all	4/1/2004	5/4/2004	2	1
7	WC503432-015	Chiwawa	Marble at mouth	B	4/2/2004	5/27/2004	4	4/20/2004	2,3,4	N/A	N/A	0	0
8	WC503432-060	Nason	Nason at Butcher	B/K	4/6/2004	5/24/2004	4	4/6/2004	all	4/6/2004	5/24/2004	1	0
9	WC503432-021	Wenatchee	Wenatchee in Plain	C	4/1/2004	5/27/2004	8	WDFW		3/28/2004	5/16/2004	19	10
10	WC503432-022	Chumstick	Chumstick at Moon	W	4/14/2004	5/11/2004	4	4/14/2004	all	N/A	N/A	0	0
11	WC503432-024	Peshastin	Peshastin, Camas to Mill	C	3/15/2004	5/31/2004	10	WDFW		N/A	N/A	2	0
12	WC503432-025	Chumstick	Sunitsch Cyn	W	3/24/2004	5/11/2004	4	3/24/2004	all	N/A	N/A	0	0
13	WC503432-152	Tronsen	Tronsen at Blewett Pass	W	3/26/2004	5/6/2004	4	3/26/2004	all	N/A	N/A	0	0
14	WC503432-027	Peshastin	Middle Shaser	W	4/7/2004	4/30/2004	3	4/7/2004	all	N/A	N/A	0	0
15	WC503432-029	Tronsen	Tronsen at Bonanza CG	W	3/26/2004	5/6/2004	4	3/26/2004	all	N/A	N/A	0	0
16	WC503432-153	Nason	Nason at Mill	B/K	4/13/2004	5/24/2004	3	5/24/2004	3,4	N/A	N/A	0	0
17	WC503432-032	Nason	Nason at Kahler	B/K	4/6/2004	5/24/2004	4	4/6/2004	all	N/A	N/A	0	0
18	WC503432-035	Chumstick	Dry Creek	W	3/31/2004	4/29/2004	4	4/8/2004	2,3,4	N/A	N/A	0	0
19	WC503432-042	Chumstick	Chumstick at Eagle	W	4/1/2004	5/12/2004	6	4/13/2004	2,3	4/22/2004	4/22/2004	2	0
20	WC503432-046	Peshastin	Negro Creek	B	3/23/2004	4/30/2004	3	3/23/2004	unk, 2,3	N/A	N/A	0	0
21	WC503432-047	White	White River at mouth	B/K	3/29/2004	5/26/2004	4	3/29/2004	all	N/A	N/A	0	0
22	WC503432-048	Chiwawa	Beaver at mouth	W	4/2/2004	5/17/2004	5	4/2/2004	all	4/2/2004	5/17/2004	15	29
23	WC503432-049	Mission	EF Mission	B & W	3/25/2004	5/10/2004	4	3/25/2004	all	N/A	N/A	0	0
24	WC503432-054	Peshastin	Ingalls at barrier	B	5/4/2004	5/27/2004	3	5/4/2004	all	N/A	N/A	0	0
25	WC503432-058	Lake Wenatchee	Plainview at mouth	W	4/7/2004	5/25/2004	4	4/7/2004	all	N/A	N/A	0	0
26	WC503432-065	Chiwawa	Chiwawa at Willow	B/K	5/18/2004	6/2/2004	3	5/18/2004	all	N/A	N/A	0	0
27	WDFW trend	Wenatchee	L. Wenatchee	K	4/15/2004	5/21/2004	10	N/A	N/A	N/A	N/A	0	0

Survey method: W = wade, B = bank, B/K = surveyed from bank in 2004 but suggested to kayak, K = kayak, C = cataraft.

Timing of surveys and steelhead activity

In our 7 reaches with ST activity, the date of first detected activity was between 3/28/04 and 4/22/04. The date of last activity was between 5/3/04 and 5/24/04 (table one).

Based on 2004 data from these 6 reaches, most redds were visible unfaded² for 10-20 days and were visible (unfaded or faded) for 20-37 days (see table 2 below). In one stream (Beaver Creek) some redds were completely erased (no longer visually identifiable as this year's redd) in 11-12 days. In our other streams, redds were not erased until 20 or more days after the first sighting of the redd. WDFW has more data on time till fading and erasure in several Wenatchee basin streams over several years.

In 19 of our reaches, the first survey occurred between 3/14 and 4/7 (table 1). In eight other reaches physical conditions, or a delay in landowner permission, delayed the first survey until 4/13 – 5/18. Our last survey of each reach occurred between 4/29 and 6/2.

Timing of steelhead spawning is thought to be linked to flow volume and to water temperature. It is generally thought that in the Wenatchee basin, steelhead do not begin to spawn until water temperature rises to 38.5 F or higher (M. Tonseth, WDFW, pers. comm.).

In 22 of our surveyed reaches, water temperature was above 38.5³ F on each visit (table 1). In the remaining four reaches water temperature did not exceed 38.5 F on the first visit, but did exceed 38.5 F on at least 2 visits to the reach. Based on the above timing and temperature data, we feel we were unlikely to miss the entire spawning run at any of our sites.

In Chumstick Creek, water temperatures were well above 38.5 F on each visit (44 F on the first visit 4/1/04). However spawning did not occur until the 4th visit (5/22) when flows were lower. A helpful landowner who showed our surveyors last year's redds (this year's redds were dug in nearly the same location) repeatedly told our surveyors on their first visits that they were too early and the fish would not spawn until the flow dropped; therefore this may be a typical pattern across years. We may have observed only a small portion of the spawning in Chumstick watershed, or Chumstick spawning may occur in a short time-window; a 5th and 6th visit to Chumstick Creek did not reveal any further spawning.

Table 2 gives data on each redd observed. Redd locations are shown in figure 2.

² See definitions of “faded” and “erased” in Appendix C.

³ All water temperatures reported here are as recorded by the instrument. However certain thermometers, including those used at sites 38, 63, 9, 15, 22, 25, 153, 35, 42, 46, 47, 48, 49, 54, and 65, may have read about 1.5 F too low (see Appendix A).

Table 2: Steelhead Redd Summary

Site num	Watershed	Stream	Redd numbers	Date first seen	Last date unfaded	First date faded	First date erased	Date of last survey	Num_days visible unfaded	Num_days visible faded	Num_days from first seen until erased
WC503432-001	Nason	Nason Creek	Nason 1-1	4/14/2004	5/3/2004	--	--	5/3/2004	20	--	--
WC503432-001	Nason	Nason Creek	Nason 1-2	4/14/2004	5/3/2004	--	--	5/3/2004	20	--	--
WC503432-011	Peshastin	Peshastin at mouth	Peshastin 11-1	4/1/2004	4/15/2004	5/4/2004	--	5/4/2004	15	19	--
WC503432-011	Peshastin	Peshastin at mouth	Peshastin 11-2	4/1/2004	4/15/2004	5/4/2004	--	5/4/2004	15	19	--
WC503432-060	Nason	Nason at Butcher	Nason 60-1	4/6/2004	4/21/2004	--	5/13/2004	5/24/2004	16	--	37
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-8	3/28/2004	4/22/2004	4/29/2004	--	5/25/2004	26	27	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-9	4/1/2004	5/25/2004	--	--	5/25/2004	55	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-16	4/22/2004	5/25/2004	--	--	5/25/2004	34	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-31	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-32	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-33	4/29/2004	5/25/2004	--	--	5/25/2004	27	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-34	4/29/2004	5/25/2004	--	--	5/25/2004	27	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-35	4/29/2004	5/25/2004	--	--	5/25/2004	27	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-36	4/29/2004	5/25/2004	--	--	5/25/2004	27	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-40	5/18/2004	5/25/2004	--	--	5/25/2004	38	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-41	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-42	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-43	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-44	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-45	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-46	5/12/2004	5/25/2004	--	--	5/25/2004	14	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-53	5/18/2004	5/25/2004	--	--	5/25/2004	38	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-54	5/18/2004	5/25/2004	--	--	5/25/2004	38	--	--
WC503432-021	Wenatchee	Wenatchee in Plain	Wenatchee 21-55	5/25/2004	5/25/2004	--	--	5/25/2004	--	--	--
WC503432-024	Peshastin	Peshastin - Camas	Peshastin 24-1	3/29/2004	5/31/2004	--	--	5/31/2004	63	--	--
WC503432-024	Peshastin	Peshastin - Camas	Peshastin 24-2	3/29/2004	5/31/2004	--	--	5/31/2004	63	--	--
WC503432-042	Chumstick	Chumstick at Eagle	Chumstick 42-1	4/22/2004	4/22/2004	5/5/2004	5/12/2004	5/12/2004	--	7	20

WC503432-042	Chumstick	Chumstick at Eagle	Chumstick 42-2	4/22/2004	5/5/2004	--	5/12/2004	5/12/2004	14	--	20
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-1	4/2/2004	4/2/2004	--	4/13/2004	5/17/2004	--	--	11
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-2	4/13/2004	4/23/2004	--	5/5/2004	5/17/2004	11	--	22
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-3	4/23/2004	5/5/2004	--	5/17/2004	5/17/2004	13	--	24
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-4	4/23/2004	4/23/2004	5/5/2004	5/17/2004	5/17/2004	--	12	24
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-5	4/23/2004	4/23/2004	5/5/2004	5/17/2004	5/17/2004	--	12	24
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-6	4/23/2004	5/5/2004	--	5/17/2004	5/17/2004	13	--	24
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-7	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-8	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-9	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-10	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-11	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-12	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12
WC503432-048	Chiwawa	Beaver at mouth	Beaver 48-13	5/5/2004	5/5/2004	--	5/17/2004	5/17/2004	--	--	12

Discussion

The year-one data from the rotating panel steelhead surveys brought to light:

- New biological information
- Logistical concerns
- Analysis concerns
- Suggestions for future refinement of site selection

New Biological Information

Steelhead activity was observed at seven locations (six reaches plus one training site). Steelhead were already known to spawn at four of these sites, but new information was gained at three sites.

At Peshastin site 11 (Peshastin Creek mouth), steelhead were known to move above this site to spawn, but this was the first record of Steelhead spawning this low in the river. In Chumstick Creek, radio telemetry surveys conducted in 2000 had shown steelhead migrating throughout the creek as early as 17 April (English et al. 2001), but these were the first documented redd sites in Chumstick Creek. In Beaver Creek, steelhead had been observed above the first culvert (C. Kamphaus, YN, personnel communication), but this was the first documentation of redd sites for Beaver Creek. Also, the number of steelhead adults and redds in Beaver Creek was higher than previously recorded.

Logistics

1) Barrier information incomplete in a few locations.

Although in general we have good barrier information throughout the basin, some random sites fell in spots where barrier information was incomplete, and infeasible to collect during the steelhead field season due to large numbers of private landowners involved. In 2004 four surveys were conducted on sites of uncertain barrier status (Spromberg, Sunitsch, Chumstick at Moon, and Dry Creek; all small tributaries of Chumstick Creek).

2) Non-uniform detection probability

Applying the non-random steelhead redd protocol at randomly selected sites raises some new logistical concerns. Sites will vary much more widely in 1) access method, timing, method and cost and 2) type of survey (bank, wade or water) feasible. In the Wenatchee basin in 2004 random sites may also have varied more than WDFW sites in substrate visibility and temperature regime. Survey type and detection probability should be explicitly considered in analysis.

Future randomly-located steelhead surveys may wish to collect additional data related to probability of detection, such as:

- Percent of substrate visible (function of turbulence, turbidity, depth).
- Percent of substrate observed (function of percent visible, survey method, stream width (and did survey cover entire width each visit or alternate sides on alternate visits), and side channels (were they surveyable with given survey method and how often were they surveyed).
- Survey type should be recorded.

3) Reduce reliance on bank-walking surveys, where safety and logistics allows.

In wider streams, bank walking should be avoided if an on-the-water method can be safely utilized.

Four 2004 random surveys were conducted by boat: Wenatchee-Plain, Wenatchee-Monitor, Peshastin-Camas, and Little Wenatchee. 2004 surveys that might have been more effectively surveyed by boat include: Nason-Kahler, Nason-Butcher, Nason-Coles, White, Chiwawa-Big-Meadow, Chiwawa-Willow, and Peshastin-mouth.

4) Consider different survey lengths for different survey types.

Given that survey probability likely already varies with survey method, future surveyors may wish to consider varying length of survey with method. Surveys done by boat can cost-effectively cover much longer reaches than surveys by foot; boat surveyors will likely be constrained by put-in and take-out logistics and may need to be on the water for more than one mile in any case.

Analysis

Of our 28 reaches, 6 had steelhead present and 22 did not. This high proportion of “zero” (no steelhead activity) reaches will give low statistical power and high standard deviation when analyzing trends over time. “Zero” reaches do provide valuable information over time and are of value in the steelhead reach database. Also, steelhead absence from high quality habitat is different information than absence from low quality habitat. Therefore we suggest refinement of the reach stratification process.

Statistical power can be increased by sampling:

- More sites
- Longer sites
- More likely sites

In 2004, stratification was largely based on stream gradient and order. Stevens 2002 (cited from Hillman 2004) gives examples of stratification based on habitat quality. Stevens emphasizes the need to sample all strata (even lowest quality) although you need not sample all strata with equal intensity. Stevens also emphasizes the need to post-check habitat categorization through empirical measurements.

Here is one example of a 5-tiered habitat quality stratification. A given basin might not contain all tiers, but could use those present.

- Tier one: redds or adults previously detected in or above stream reach by radiotelemetry, redd survey, or direct observation of fisheries biologist.
- Tier two: credible reports of current steelhead presence from fishermen, or other sources.
- Tier three: credible reports of historic steelhead presence from fishermen, or other sources.
- Tier four: Good habitat in professional opinion of biologists (use best pre-existing data to categorize). Develop field criteria for post-categorization. Field criteria could include parameters such as thalweg depth, spawning gravel presence, and stream temperature.
- Tier five: Poor habitat based on the same pre-existing and post-categorization data as above.

To detect trends over time, the sites visited should be stable across time, not constantly adaptively re-stratified. Therefore a stratification based on habitat quality should allow for extra effort for the first year of a given panel. Options include habitat assessment field visits before the season; or plan for a “first” visit to many sites from which the stable 25-site panel would be selected.

Assuming one wishes to include the greatest possible sampling universe (for example all reaches of grad < 12% that are not above definite barriers), the use of varied survey methods (boat, wade, etc.) will be unavoidable, and will unavoidably create different probabilities of detecting redds should they be present (due to varying observer speed, water depth, proportion of bottom visible, etc.).

Since detection probability may vary even with uniform reach length, and will need to be explicitly considered in the analysis in any case, we may wish to consider using different reach lengths for different survey methods.

In any analysis of spawning timing, water temperature may be as or more important than date. Water temperature should be explicitly considered in field sampling and in analysis.

Acknowledgements

Funding was provided by Bonneville Power Administration. We thank Washington Dept of Fish and Wildlife for assistance with training, protocol, data formats, and raft surveys. Thanks also to Chelan County Conservation District for contacting private landowners, and to the many private landowners who allowed access across their property.

Appendix A: Reach Selection

This list of random sites was generated from sites on 1:100,000 stream layer with GIS-calculated gradient less than 12%. A weighting scheme was used to emphasize selection of moderate gradient streams of 4th order and smaller.

Criteria for eliminating sites:

1. Above an anadromous barrier.
2. Line layer error; i.e. the point is actually within a lake or side channel and should not have been on the list.
3. Sites falling within reaches already surveyed weekly by USFWS were dropped. Sites falling within reaches surveyed once annually by USFWS were retained. An exception was Chiwawa above Chikamin, which is surveyed from water once annually by USFWS; we attempted to survey this site once and determined it could not be effectively surveyed from the bank.
4. The stream segment in question does not contribute to fish production (even through aquatic macro-invertebrate production) in any season.
5. Safety.
6. Accessibility.

Table A1 shows all sites considered and why sites were dropped.

Table A1: Steelhead Redd Site Selection

SitelD	ST_Red d Site	panel	description	Private	redd comment	GIS LOC	GIS SIN	GIS % GRAD	GIS STRAHL ER
WC503432-001		1 Annual	Nason below Coles corner		Drive access. Bank walk. Could float?	MOUTH	1.14	0.32	4
WC503432-002	DROP	Annual	L. Wenatchee below Meander Meadows		drop -- barrier	TRANS	1.03	3.82	2
WC503432-003		2 Annual	Wenatchee below Monitor	Y	WDFW surveyed for FS in 2004	TRANS	1.00	0.29	5
WC503432-004	DROP	Annual	ephemeral trib of Derby		drop from entire project -- no fish production	SINGLE	1.02	10.71	1
WC503432-005	DROP	Annual	Ollalla		drop from entire project -- no fish production	TRANS	1.03	1.03	3
WC503432-006	DROP 2004	Annual	5 miles up French Ck		drop -- barrier at hatchery for 2004 at least	TRANS	1.06	1.67	3
WC503432-007	DROP	Annual	tributary of Brush Ck		Drop. No access due to 3 ft jump into culvert and several beaver ponds.	HEAD	1.09	11.35	1
WC503432-008	DROP	Annual	White above Boulder Ck		drop -- barrier	TRANS	1.13	1.04	3
WC503432-009		3 Annual	Spromberg	Y	Short walk	TRANS	1.01	3.37	2
WC503432-010	DROP	Annual	upper Hardscrabble		drop -- barrier	SINGLE	1.07	11.95	1
WC503432-011		4 Annual	Peshastin mouth	Y	Bank walk. Access along gravel pit etc to avoid private impacts	TRANS	1.00	2.17	3
WC503432-012	DROP 2004	Annual	Icicle near Doughgod		drop -- barrier at hatchery for 2004 at least.	TRANS	1.08	1.65	3
WC503432-013	DROP	Annual	Twin Lakes outlet		drop -- barrier	TRANS	1.05	3.35	2
WC503432-014	DROP	Annual	upper Napeequa		drop -- barrier	TRANS	1.17	1.90	2
WC503432-015		5 Annual	Half mile up Marble		Snowmo or drive then snowshoe	SINGLE	1.14	4.87	1
WC503432-016	DROP	Annual	lower Napeequa		Drop because anadromous barrier occurs mid-reach	MOUTH	1.23	1.41	3
WC503432-017	DROP	Annual	lower Chiwawa	Y	Already surveyed by WDFW	MOUTH	1.22	0.77	4
WC503432-018	DROP	Annual	Icicle mouth	Y	Already surveyed by WDFW	TRANS	1.13	0.13	4
WC503432-019	DROP	Annual	Rock above barrier		drop -- barrier	TRANS	1.06	7.21	2
WC503432-020	DROP	Annual	Little Wenatchee side channel below Lost		drop from entire project because in side channel	OTHER	1.10	0.10	1
WC503432-021		6 Annual	Wenatchee in Plain	Y	WDFW surveyed for FS in 2004	TRANS	1.13	0.40	5
WC503432-022		7 Annual	Chumstick above Moon	Y	Drive access. Very small and poor habitat. Barrier analysis needed.	TRANS	1.03	2.89	3
WC503432-023	DROP	Annual	middle Napeequa		drop -- barrier	TRANS	1.06	1.51	3
WC503432-024		8 Annual	Peshastin near Camas	Y	bank walk.	TRANS	1.03	1.91	3

WC503432-025	9	Annual	Sunitsch	Y	Very unlikely habitat.	HEAD	1.13	5.64	1
WC503432-026	DROP	Year1	Trout at lake outlet		drop -- no winter access	HEAD	1.04	8.03	1
WC503432-027	10	Year1	Middle Shaser about 1/2 mi above mouth	?	May snowshoe or ski early surveys, drive access later surveys.	HEAD	1.03	9.79	1
WC503432-028	DROP 2004	Year1	Icicle near Sleeping Lady	Y	drop -- barrier at hatchery for 2004 at least	SINGLE	1.09	0.36	1
WC503432-029	11	Year1	Tronsen below Bonanza Campground		Drive access.	TRANS	1.00	2.64	2
WC503432-030	DROP	Year1	unnamed trib W of Monitor		drop -- barrier	TRANS	1.01	6.73	1
WC503432-031	DROP	Year1	Cougar Creek		drop -- barrier	SINGLE	1.06	6.89	1
WC503432-032	12	Year1	Nason above Kahler	Y	Bank walk with drive access. Could float?	TRANS	1.29	0.69	4
WC503432-033	DROP	Year1	Napeequa River		drop -- safety	TRANS	1.01	3.19	3
WC503432-034	DROP	Year1	French Potholes outlet		drop -- no winter access	SINGLE	1.09	10.75	1
WC503432-035	13	Year1	Dry Creek (Chumstick)	Y	Drive access. Very small and poor habitat. Barrier analysis needed.	HEAD	1.01	7.34	1
WC503432-036	DROP	Year1	Ingalls just above mouth	Y	Already surveyed by WDFW	TRANS	1.02	3.98	2
WC503432-037	DROP	Year1	Little Wenatchee below Lake Ck		drop -- barrier	TRANS	1.11	1.48	4
WC503432-038	(DROP)	Year1	Chiwawa above Chikamin		Made one visit. Could not be effectively surveyed from bank. WDFW floats one annual visit, has never found redds.	TRANS	1.29	0.00	4
WC503432-039	DROP	Year1	White above Napeequa	?	Already surveyed by WDFW	TRANS	1.09	0.36	4
WC503432-040	DROP	Year1	1/2 mile up Solomon (trib of Jack)		drop -- barrier at hatchery for 2004 at least.	SINGLE	1.00	8.39	1
WC503432-041	DROP	Year1	Anderson Canyon	Y	drop -- barrier	MOUTH	1.07	4.61	1
WC503432-042	14	Year1	Chumstick at Eagle	Y	Drive access. Wadable.	TRANS	1.05	1.39	3
WC503432-043	DROP	Year1	Icicle above Trapper		drop -- barrier	HEAD	1.03	6.87	1
WC503432-044	DROP	Year1	Sunnyslope trib		drop -- no surface connection	SINGLE	1.01	11.93	1
WC503432-045	DROP	Year1	Snow Creek		drop -- barrier	TRANS	1.05	9.90	2
WC503432-046	15	Year1	Negro near RM 3 below barrier		Snowshoe. Bank walk.	MOUTH	1.25	6.96	2
WC503432-047	16	Year1	White at mouth	?	Should be float survey (kayak).	TRANS	1.22	0.03	4
WC503432-048	17	Year1	Beaver near mouth	Y	Wadable.	TRANS	1.25	1.76	2
WC503432-049	18	Year1	East Fork Mission Ck RM 1		Drive access.	TRANS	1.04	2.76	3
WC503432-050	DROP	Year1	Slawson Cyn (lower Mission trib)		drop from entire project. No surface connectivity.	SINGLE	1.01	8.83	1

WC503432-051	DROP	Year2	Cabin Creek		drop -- barrier	TRANS	1.06	4.17	2
WC503432-052	DROP	Year2	Jack Creek		drop 2004 (hatchery barrier)	MOUTH	1.05	4.38	3
WC503432-053	DROP	Year2	White River		drop -- barrier	TRANS	1.04	0.21	3
WC503432-054		19 Year2	Ingalls below BT barrier		Very difficult access.	TRANS	1.02	3.28	2
WC503432-055		20 Year2	Chiwawa at Big Meadow		Should be float survey when flows allow.	TRANS	1.07	0.91	4
WC503432-056	DROP	Year2	Chiwaukum above S Fk		drop -- barrier	TRANS	1.03	4.22	4
WC503432-057	DROP	Year2	Little Wenatchee at Theseus		drop -- barrier	TRANS	1.07	0.98	4
WC503432-058		21 Year2	Plainview Creek	?	Very small, very unlikely habitat. In < one mi, gradient exceeds 12%.	HEAD	1.04	3.94	1
WC503432-059	DROP	Year2	White R headwaters		drop -- barrier	TRANS	1.03	4.99	2
WC503432-060		22 Year2	Nason at Butcher	Y	Bank walk with drive access. Could float?	TRANS	1.07	0.22	4
WC503432-061	DROP	Year2	Little Wenatchee below falls		Already surveyed by WDFW	TRANS	1.05	1.78	4
WC503432-062	DROP	Year2	Poison Ck headwaters		drop from entire project -- no fish prod	SINGLE	1.03	5.94	1
WC503432-063		23 Year2	Rock Creek near mouth		Snowmobile early season; late season access uncertain (patchy meltout)	MOUTH	1.07	3.01	3
WC503432-064	DROP-NFP	Year2	Douglas Creek		Drop from entire project. No fish prod. No surface connectivity at mouth. Dry by June.	SINGLE	1.04	4.94	1
WC503432-151	DROP	OverSam p	Little Wenatchee above Rainy		drop -- barrier	TRANS	1.10	0.93	4
WC503432-152		24 OverSam p	Tronsen along Hwy 97 about 2 mi N Swauk Pass		road access	TRANS	1.03	4.33	2
WC503432-153		25 OverSam p	Nason at Mill	?	Snowshoe bank survey. Use great caution on steep banks with rotten snow.	TRANS	1.09	1.70	3
WC503432-154	DROP	OverSam p	Turnpike (Ingalls trib)		drop -- barrier	SINGLE	1.04	5.35	1
WC503432-155		26 OverSam p	Peshastin at Larsen	Y	WDFW surveyed for FS in 2004	TRANS	1.00	1.70	3
WC503432-156	DROP	OverSam p	Icicle at Rat Ck	?	drop -- barrier	TRANS	1.03	3.16	4
WC503432-157	DROP	OverSam p	trib of Cady Ck flowing from Lake Sally Ann		drop -- barrier	SINGLE	1.04	5.05	1
WC503432-158	DROP	OverSam p	White Pine Creek		drop -- barrier	HEAD	1.04	4.89	1

Appendix B: Redd Categorization Definitions

Incomplete: A steelhead has disturbed the substrate, but there is not a clear pit and tail.

Complete: Gravels are clean due to fish activity and there is a distinct pit and tail.

Faded: Still visible, but may be “flattened out” or no longer bright (algal growth).

Erased: A surveyor would not identify it as this year’s redd had it not already been surveyed.

Appendix C: Thermometer Calibration

Handheld thermometer calibration for 2004											
All temperatures in F											
		Ice bath					Water bath				
		June 1,04		June 8,04			June 1,04	June 8,04		June 8,04	
therm type	purchase yr - num	ice bath 1	deviation from 32F	ice bath 2	deviation from 32F	deviation from unit 02-1	water bath 1	water bath 2	deviation from unit 02-1	water bath 3	deviation from unit 02-1
taylor digital	02-1			32.5	0.5	0.0		54.9	0	60.6	0
taylor digital	04-01	30.7	-1.3	30.9	-1.1	-1.6	64	53.2	-1.7	59	-1.6
taylor digital	04-02	30.7	-1.3	30.7	-1.3	-1.8	63.9	53.2	-1.7	58.8	-1.8
taylor digital	04-03	30.9	-1.1	31.1	-0.9	-1.4	64.2	53.6	-1.3	59	-1.6
taylor digital	04-04	30.7	-1.3	30.7	-1.3	-1.8	64	53.4	-1.5	58.8	-1.8
taylor digital	00-1			34.0	2.0			55.4	0.5	61	0.4
	range 04-01 to 04-04	0.2		0.4			0.3	0.4		0.2	
	average deviation from 02-1					-1.7			-1.6		-1.7
Conclusions:											
The thermometer purchased in 2002 is relatively accurate near freezing and was used as the reference thermometer.											
The thermometers purchased in 2004 were relatively consistent and probably all read about 1.5 F low across a range of temperatures.											
The thermometer purchased in 2000 was 0.5 - 2 F high depending on temperature and should not be used.											

Appendix D: GPS Protocol and Calibration

GPS Protocol:

The following six requirements must be met every time you use your GPS.

1. Make sure you have spare batteries for your survey day. Most handhelds will run 10 hrs on a set of batteries.
2. Run the Trimble planning software to see what your gps satellite coverage is going to be during the period you are planning to be in the field. Go to the station menu item and pick Leavenworth out on the map display. Set today as the date (or whatever date you want to evaluate). You need to decide what is the angle of your horizon is for your sites and enter that in the software. I would recommend that you look at both 20 and 30 degrees. The graph you want is under Graphs, Horizontal DOP (dilution of precision). A dop of 5 or higher isn't very good, but you should be aware that the display is just an approximation since your angle to the horizon is not going to be uniform. Rather than not attempting to log a position at a certain time I would use the graph as a "if I am having trouble getting a good fix, then I can look at the graph to see when I might get a better fix."
3. Make sure your gps is set to display and log data using WGS 84 datum and decimal degrees. (Gps systems native position format is WGS 84 lat and long. Any other map projection needs to be reprojected by the gps unit itself and thus is another variable affecting accuracy.) and that your gps is set to position average for at least 2 minutes. Figure out how your gps needs to be held to get the best signal strength. The Garmin e series needs to be held flat, most others do better held up and down.
4. When you are getting ready to log a position or navigate to an already established position, turn the gps on in a spot with a good view of the sky and wait for it to lock onto as many satellites as it can before you go into a location with a poor view of the sky. The receiver needs to download a complete set of orbital data for each satellite before it can lock on and use that satellite for navigation. If it can't download that initial info under heavy canopy or if the downloads keep getting interrupted the receiver will never be able to lock onto that satellite. When all of the satellite bars have turned solid then the receiver has downloaded all the info it needs from each satellite and is using each satellite for navigation. Four satellites are the minimum needed for navigation. More than 7 is usually good. You will also be able to tell when the gps is ready by watching the epe (estimated position error) display. As more satellites are locked onto and the satellite position info is downloaded then the epe value should decrease. When it stabilizes you are ready to go. An epe value of 30' or less is good, above 50' is not very good and beyond 100' is probably not very usable. Likewise if the epe is varying widely 30' to 80' to 150' and back, then that isn't very good either. In one recent test several gpses wandered up to 1 km while stationary due to poor accuracy of the time signals from the satellites (atmospheric interference, poor satellite geometry, few satellites, etc). Fortunately this situation is rare but the signs of it are a high epe (above 100') and lat, long position that is changing rapidly. (0.0001° lat = 36', and 0.0001° long = 21')
5. When are ready to log a point use the waypoint averaging feature on your gps if you have one. I would recommend at least 2 minutes of averaging, up to 10 minutes. If you don't have waypoint averaging then you can watch the display for 2 minutes and record the range of values that the machine displays. Before you start logging wait several minutes after you turn the gps on to let it

lock onto as many satellites as it can and download all the satellite position data that it needs described in section 4 above. On the satellite screen you can find which satellites are in the sky and which it is currently receiving (grey bar or clear bar) and which it has locked onto (black bar).

6. On the data sheet, record the datum you are using (WGS84 is the suggested one to use but put down what you used), number of satellites that the machine has locked onto at the beginning and end of the period (more than 7 is good, 4 is the bare minimum), the epe (estimated position error) or accuracy or fom (figure of merit, another measure of accuracy for some garmin receivers) at the beginning and end of the period, and the model of gps, and the latitude, longitude, (and the range of latitude, longitude values if your gps doesn't position average).

GPS Calibration:

Before purchasing our GPS's in 2004, we undertook a GPS brand comparison that included a literature search and a field comparison under moderately dense coniferous canopy (details below).

Once we selected a model to purchase, we put each unit through a two-step calibration.

Step one: Comparison to survey-grade post-processed site.

Forest Service Engineering Department has collected a post-processed latitude-longitude at a known location with an open view of the sky using survey grade Trimble Geo-Explorer. All of our units were tested at this location; all had two-minute averages within 20 ft of the post-processed position.

Step two: Group comparison in gully under canopy of a densely stocked 3-10-inch-dbh Douglas Fir stand; gully walls obscured horizon 25-30 degrees in all directions. At this site, each unit was logged each second for at least 2 hours. Both the 2-minute-moving-average and the total average for all units agreed to within 10 m.

GPS Brand Comparision

At the time of our research, www.gpsinformation.net reported that the Magellan Sport Trak Pro was one of the most accurate non-survey-grade units they had ever tested. Comparison with a variety of other units at the above-described densely-stocked gully site confirmed that this brand outperformed others in forested field conditions. (See table below.)

GPS COMPARISONS			MODERATE TREE CANOPY W REDUCED VIEW OF S AND W HORIZON								
			LOGGING	ERROR	MEAN POS	BEARING	MOVING AVG ERR	MOVING AVG	ALL POS ERR	TIME UNTIL AVG POS	
MAKE	MODEL	REP	LEN	RANGE	ERR		94% Percentile	PERIOD	95% Percentile	IS WITHIN x M OF FINAL	
			hr:min	meters	meters		meters	min:sec	meters	5 M	10 M
										min:sec	min:sec
Magellan	Sport Trak Pro	1	1:02	9	0.3	220	5.8	0:50	1.7	0:01	0:01
		2	0:16	11	1.8	65	2.8	0:50	5.1	0:01	0:01
		3	2:08	10	3.3	61	2.9	0:50	5.9	10:00	0:01
		4	0:22	11	3.8	33	5.2	0:50	6.9	0:01	0:01
		5	2:14	11	3.9	47	3.4	0:50	7.1	0:30	0:01
	Meridian Color	1	1:20	10	5.1	39	5.7	0:50	6.0	2:00	0:01
CMT	March II	1	1:44	100	3.5	131	6.9	0:51	15.0	0:01	0:01
Garmin	12xl	1	1:51	130	5	342	6.6	1:00	25.0	10:00	5:00
	12gc	1	3:24	150	2.2	149	21.4	1:35	20.0	3:00	1:30
	3-Plus	1	3:24	120	3.7	149	21.4	1:35	20.0	2:00	1:30
		2	0:35	25	2.5	35	10.3	1:40	11.0	0:30	0:01
	Map76S	1	3:04	120	2.2	21	13.7	1:40	20.0	0:30	0:01
		2	1:42	40	1.1	117	8.6	1:40	9.6	2:00	0:01
	Etrex Venture	1	1:16	110	0.7	319	6.3	1:40	15.0	10:00	8:00
	Etrex Summit	1	1:15	16	2.1	133	5.4	1:40	7.1	5:00	1:30
					2.7	124.0667					

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